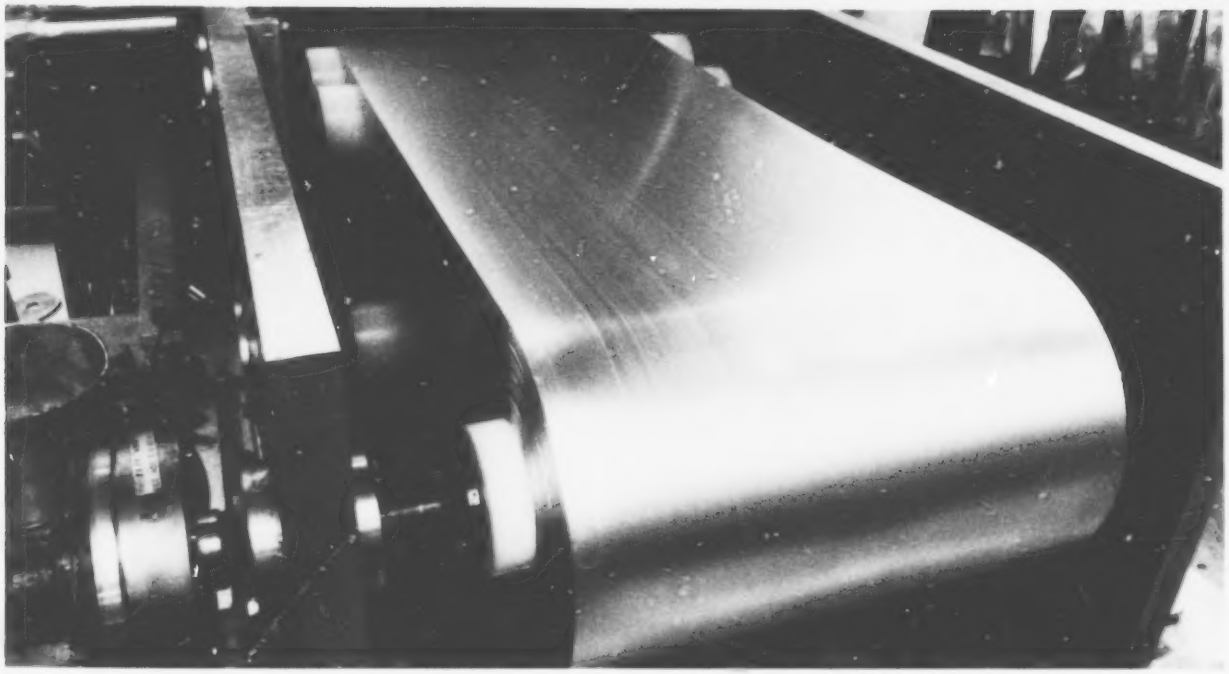
L 713/989



LITHIUM

By Joyce A. Ober

1989

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

I 28 37/a:

READEX FICHE best copy available

LITHIUM

U.S.
DEPARTMENT
OF THE
INTERIOR

Manuel Lujan, Jr.
Secretary

BUREAU
OF
MINES

T S Ary
Director

September 1990

Contents

Domestic Data Coverage 1
Legislation and Government Programs 1
Production 1
Consumption and Uses 2
Prices 2
Foreign Trade 3
World Review 3
  Capacity 4
  Australia 4
  Bolivia 5
  Canada 5
  Chile 5
  Namibia 6
  Zimbabwe 6
Current Research 7
Outlook 8

COVER PHOTO:
Lithium metal is unique in its high degree of reactivity and its low density, making it a material-of-choice for innovative battery technologies and aerospace alloys. Extrusion machines form extremely thin lithium foils, as shown here, for use in batteries. (Photo is courtesy of Cyprus Foote Mineral Co.).

Tables

Table 1.—Salient Lithium Statistics 1
Table 2.—Domestic Yearend Producers' Average Prices of Lithium and Lithium Compounds 2
Table 3.—U.S. Exports of Lithium Chemicals, by Compound and Country 3
Table 4.—U.S. Imports for Consumption of Lithium-Bearing Materials, 1988 6
Table 5.—U.S. Imports for Consumption of Lithium-Bearing Materials, 1989 6
Table 6.—World Lithium Annual Production Capacity, December 31, 1989, Rated Capacity 7
Table 7.—Lithium Minerals and Brine: World Production, by Country 7

For comments or further information, please contact
The Branch of Industrial Minerals
The Division of Mineral Commodities
Bureau of Mines
2401 E St., NW, MS 5209
Washington, DC 20241-0001
Telephone: (202) 634-1177
FAX: (202) 634-4091

LITHIUM

By Joyce A. Ober

Mrs. Ober, a physical scientist with 12 years industry and Bureau of Mines experience, has been the commodity specialist for lithium since 1986. Domestic survey data were prepared by Carleen Militello, mineral data assistant, and international data tables were prepared by Peter J. Roetzel, international data assistant.

The United States led the world in lithium mineral and compound production and consumption. Estimated consumption increased slightly, and world production also grew. Sales increased for domestic producers, who announced price increases for the third consecutive year.

Because lithium is electrochemically reactive and has other unique properties, there are many commercial lithium products. Producers sold lithium as mineral concentrate, brine, compound, or metal, depending upon the end use. Most lithium compounds were consumed in the production of ceramics, glass, and primary aluminum.

DOMESTIC DATA COVERAGE

The Bureau of Mines collects domestic production data for lithium from a voluntary survey of U.S. operations. The two U.S. companies responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data. The metric system is the official system of measurement of most countries. The Bureau of Mines, in an effort to provide statistical data on lithium in units most consistent with international usage, will henceforth report data in kilograms and metric tons unless otherwise noted.

LEGISLATION AND GOVERNMENT PROGRAMS

The Department of Energy (DOE) planned to offer portions of its 36 million kilograms of lithium hydroxide monohydrate for sale. The DOE stocks were excess from a weapons program that used the lithium to make tritium, a compound necessary for nuclear fission reactions. The stockpile originally contained about 42,000 tons of material, from which about 75% of the lithium 6 isotope had been removed. This material possibly contained 8 to 9 parts per million of mercury. Because of mercury contamination, DOE delayed the proposed disposal of lithium hydroxide until an environmental impact study was complete.

PRODUCTION

The two companies that produced lithium in the United States in 1989 did so from two different types of deposits. Both firms mined spodumene, (a lithium-aluminum-silicate ore) from large hard-rock deposits in North Carolina using open pit methods. Geothermal brines were a source for lithium in Nevada. Pumps remove the brine from underground deposits into evaporation ponds. Extraction processes separate lithium from the concentrated brines.

Cyprus Foote Mineral Co. produced lithium carbonate at its brine deposit in Silver Peak, NV, and produced small quantities of spodumene concentrate at its mine in Kings Mountain, NC. It operated processing facilities for downstream lithium products and metal in Frazer, PA; Sunbright, VA; and New Johnsonville, TN. The company continued to maintain its lithium carbonate plant at Kings Mountain in a care-and-maintenance status as it had since mid-1986.

Lithium Corp. of America (Lithco), a subsidiary of FMC Corp., mined spodumene from pegmatite dikes near Bessemer City, NC. The company produced lithium carbonate and a full range of downstream compounds, including lithium metal and some organic lithium

TABLE 1

SALIENT LITHIUM STATISTICS

(Metric tons of contained lithium)

	1985	1986	1987	1988	1989
United States:					
Production[1]	W	W	W	W	W
Producers' stock changes[1]	W	W	W	W	W
Imports[2]	370	610	820	1,000	630
Shipments of Government stockpile surplus[3]	1	2	4	2	—
Exports[e,4]	2,300	1,800	1,800	2,300	3,000
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,300	2,400	2,400	2,700	2,700
Rest of world: Production[e,1]	3,400	3,600	3,600	4,200	4,900

W Withheld to avoid disclosing company proprietary data.
[1] Mineral concentrate and carbonate.
[2] Compounds, concentrate, ores, and metal.
[3] Lithium hydroxide monohydrate.
[4] Compounds.

compounds, at a chemical plant located near the mine.

CONSUMPTION AND USES

The aluminum, ceramics and glass, lubricating grease, and synthetic rubber industries consumed most of the lithium minerals and chemicals. These markets were primarily related to transportation, i.e., the aircraft and automotive industries. Industrial and consumer applications also used ceramics and glass. Estimated domestic consumption increased slightly in 1989. Ceramics and glass production and aluminum smelters were the largest consumers of lithium in the United States. Aluminum producers consume little lithium carbonate in other countries.

Lithium carbonate and mineral concentrate additions in ceramics and glass manufacturing processes lower process melting points, reduce the coefficient of thermal expansion and the viscosity, and eliminate the use of more toxic chemicals. The manufacture of thermal-shock-resistant cookware (pyroceramics) consumed the majority of lithium used in the ceramics and glass industry domestically. The manufacture of black and white television picture tubes consumed significant amounts of lithium concentrates overseas. Low-iron petalite and spodumene, two lithium ores, were a source of lithium used to improve the physical properties of container and bottle glass and as a source of alumina (Al_2O_3), another important component of the glass. Glass manufacturers used lithium in container and bottle glass, enabling them to produce lighter weight, thinner walled products.

Aluminum producers added lithium carbonate to cryolite baths in aluminum potlines. The chemistry of the potline converts it to lithium fluoride, lowering the melting point of the bath, allowing a lower operating temperature for the potline, and increasing the electrical conductivity of the bath. Operators used these factors to increase production, reduce power consumption, or increase current efficiency.

The multipurpose grease industry was the third largest end use for lithium in 1988. Lithium-based greases are favored for their retention of lubricating properties over a wide temperature range; good resistance to water, oxidation, and hardening; and formation of a stable grease on cooling after melting. These greases continued to be utilized in military, industrial, automotive, aircraft, and marine applications.

Nearly all major battery manufacturers marketed lithium batteries in some configuration, and research and development continued for further substitution in applications that implement more conventional alkaline batteries. Although they represent a small percentage of total lithium consumption, sales of these batteries remained a favorable growth area for lithium consumption. Lithium batteries offer improved performance over alkaline batteries, at a slightly higher cost. Lithium batteries were used in watches, microcomputers, and cameras, and, more recently, in small appliances, electronic games, and toys. The military purchased large and small lithium batteries for a variety of military applications.

Aircraft manufacturers in several countries continued to test aluminum-lithium alloys for wing and fuselage skin and structural members of new aircraft. Use of aluminum-lithium alloys can reduce the weight of the aircraft by more than 10%, allowing significant fuel savings over the life of the aircraft. The alloys, which are 2% to 3% lithium by weight, are attractive to the aircraft and aerospace industry because of their reduced density and superior corrosion resistance compared with those of conventional aluminum alloys. These alloys face direct competition, however, from composite materials consisting of boron, graphite, or aramid fibers imbedded in polymers.

Small quantities of other lithium compounds were important to many industries. Butyllithium was a catalyst in synthetic rubber production. Lithium chloride and lithium bromide were used in industrial air-conditioning systems, commercial dehumidification systems, and in the production of sophisticated textiles. Sanitizers for swimming pools, commercial glassware, and public restrooms contained lithium hypochlorite, as did dry bleach for commercial laundries. Patients diagnosed as suffering from manic-depressive mental disorders may take medication containing a pharmaceutical grade of lithium carbonate. Lithium metal was used as a scavenger to remove impurities from copper and bronze, and anhydrous lithium chloride was used as a component in fluxes for hard-to-weld metals such as steel alloys and aluminum.

PRICES

For the third consecutive year, both domestic companies increased prices for nearly all lithium products. Prices were about 6% higher in 1989 than the

TABLE 2

DOMESTIC YEAREND PRODUCERS' AVERAGE PRICES OF LITHIUM AND LITHIUM COMPOUNDS

	1988		1989	
	Dollars per pound	Dollars per kilogram	Dollars per pound	Dollars per kilogram
Lithium bromide, 54% brine: Truckload lots, delivered in drums	4.55	10.03	4.82	10.63
Lithium carbonate, technical: Truckload lots, delivered	1.63	3.59	1.73	3.81
Lithium chloride, anhydrous, technical: Truckload lots, delivered	3.42	7.54	3.20	7.05
Lithium fluoride	5.65	12.46	5.99	11.97
Lithium hydroxide monohydrate: Truckload lots, delivered	2.07	4.56	2.19	4.83
Lithium metal ingot, standard-grade: 1,000-pound lots, f.o.b	26.70	58.86	28.30	62.39
Lithium sulfate, anhydrous	3.69	8.14	3.90	8.60
N-butyllithium in n-hexane (15%): Truckload lots, delivered	15.85	34.94	16.80	37.04

Source: U.S. lithium producers.

previous year. The close balance between supply and demand worldwide has been instrumental in improving the price situation. Although installed production capacity remained in excess of demand, the chemical plant at Kings Mountain remained inactive, and supply and demand were balanced sufficiently to maintain strong prices.

FOREIGN TRADE

The Bureau of the Census began using the Harmonized Tariff Schedule in 1989 to identify material passing through U.S. Customs. This system makes classification codes for imports and exports consistent internationally. With the adoption of new codes, import and export categories for lithium and its chemicals changed, and some formerly listed details were no longer available. International trade information will no longer be available for lithium ore concentrates or lithium metal from the Bureau of the Census. Import categories identified as lithium carbonate and lithium oxides and hydroxides replaced lithium salts and compounds. For this reason, comparisons between 1988 and 1989 trade data are not valid.

The Federal Republic of Germany, Japan, and United Kingdom were the largest importers of lithium compounds from the United States. Imported lithium ore concentrates entered the United States, but no data were available. Reports from concentrate producers and consumers indicated that U.S. imports decreased in 1989.

WORLD REVIEW

A small number of countries throughout the world produced lithium ore and brine. The United States produced the most lithium; significant quantities also were produced in Australia, Canada, Chile, China, the U.S.S.R., and Zimbabwe. Argentina, Brazil, and Namibia produced smaller quantities; production primarily consisted of ore concentrates. Portugal and Zaire have produced lithium mineral concentrates in the past.

The U.S.S.R. and China produced significant quantities of lithium car-

TABLE 3

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY

Compound and country	1988		1989	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Lithium carbonate:				
Argentina	—	—	1,041	$3,729
Austria	—	—	1,873	6,709
Australia	84,785	$280,588	18,960	77,385
Belgium	—	—	19,958	55,000
Brazil	28,939	91,448	34,336	111,114
Canada	472,416	1,597,289	362,663	1,422,124
China	38,399	84,656	—	—
Germany, Federal Republic of	2,274,105	6,237,532	2,882,128	8,506,932
India	88,684	259,180	4,542	14,169
Japan	1,633,772	4,985,716	1,429,825	4,662,880
Korea, Republic of	460,345	1,477,147	137,732	417,594
Mexico	36,836	124,211	76,699	318,681
Netherlands	171,138	502,432	362,946	1,036,790
New Zealand	1,297	14,195	36	1,585
Singapore	—	—	8,642	89,865
South Africa, Republic of	13,013	47,326	29,808	100,991
Spain	—	—	59,874	165,000
Taiwan	267,977	845,816	8,990	30,027
United Kingdom	1,512,397	4,500,385	1,708,728	4,801,594
Venezuela	3,992	13,200	336,723	1,138,668
Total[1]	7,088,096	21,061,121	7,485,504	22,960,837
Lithium carbonate U.S.P.[2]				
Australia	—	—	123,854	296,165
Belgium	—	—	4,301	31,289
Canada	—	—	41,211	549,534
El Salvador	—	—	320	9,300
Germany, Federal Republic of	—	—	5,388	68,375
Honduras	—	—	328	8,727
India	—	—	25,242	100,666
Japan	—	—	386,512	1,202,469
Korea, Republic of	—	—	270,415	810,908
Mexico	—	—	12,994	8,557
New Zealand	—	—	1,498	18,685
South Africa, Republic of	—	—	1,700	60,264
Sweden	—	—	5,648	11,454
Taiwan	—	—	239,472	708,039
United Kingdom	—	—	1,107	23,220
Venezuela	—	—	440,238	1,345,378
Total	—	—	1,560,228	5,253,030
Lithium hydroxide:				
Argentina	87,381	352,973	146,044	559,459
Australia	—	—	70,778	286,205
Austria	68,402	263,730	—	—
Belgium	—	—	110,369	384,065
Brazil	495,156	1,858,444	332,244	1,478,515
Canada	103,418	414,976	63,326	300,382

See footnotes at end of table.

TABLE 3—Continued

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY

Compound and country	1988		1989	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Lithium hydroxide—Continued				
Chile	43,199	$172,951	18,129	$68,871
Colombia	19,033	77,386	32,114	127,308
Ecuador	9,891	36,619	5,000	23,326
Egypt	19,958	77,000	—	—
France	—	—	2,164	5,819
Germany, Federal Republic of	478,852	1,695,173	1,121,636	3,625,447
Guinea	—	—	572	183,960
India	425,514	1,721,493	345,276	1,325,356
Indonesia	—	—	22,680	104,600
Israel	28,772	105,871	14,984	69,485
Italy	—	—	1,683	4,496
Japan	873,152	3,588,531	892,290	3,823,441
Korea, Republic of	167,868	674,637	113,148	462,802
Malaysia	2,000	8,159	2,599	12,608
Mexico	84,030	669,011	216,640	1,033,320
Netherlands	172,385	690,843	237,698	754,827
New Zealand	5,000	22,400	7,500	35,249
Nigeria	—	—	35,599	107,624
Pakistan	15,300	64,460	28,341	123,254
Peru	—	—	17,387	73,404
Philippines	25,401	100,240	14,337	55,807
Saudi Arabia	26,000	106,600	—	—
Singapore	51,891	192,400	77,126	311,917
South Africa, Republic of	90,844	348,062	96,218	225,569
Sweden	—	—	36,580	138,920
Taiwan	8,981	36,570	21,763	73,244
Thailand	18,688	74,367	58,722	262,566
United Arab Emirates	7,983	31,504	18,414	74,435
United Kingdom	418,208	1,515,839	518,632	1,746,624
Uruguay	1,000	4,938	998	4,920
Venezuela	40,000	164,000	11,000	46,530
Total	3,788,307	15,069,177	4,691,991	17,914,355
Lithium metal:[3]				
Australia	—	—	350	—
Belgium	—	—	4,989	—
Brazil	—	—	190	—
Germany, Federal Republic of	—	—	155,920	—
India	—	—	3,079	—
Israel	—	—	4,712	—
Japan	—	—	115,982	—
Saudi Arabia	—	—	90	—
Singapore	—	—	50,131	—
South Africa, Republic of	—	—	178	—
Taiwan	—	—	1,730	—
Turkey	—	—	78	—

See footnotes at end of table.

bonate and other lithium compounds, but specific information on the operations was limited. Companies in the Federal Republic of Germany, France, Japan and the United Kingdom produced downstream lithium compounds from imported lithium carbonate, but no minerals or brines were produced in those countries.

Capacity

The data in table 5 are rated capacity for mines and refineries as of December 31, 1989. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgement of the author, can be brought into production within a short period of time with minimum capital expenditure. Any restrictions to capacity utilization related to legal, political, or environmental restraints have been footnoted.

Lithium presented special problems during compilation of production capacities for different operations. Ore concentrate products are not comparable to lithium carbonate. Lithium carbonate was the primary compound produced at lithium chemical plants and the compound from which all other lithium chemicals were produced. Because even high-grade ore products usually contained less than 4% lithium and lithium carbonate contains nearly 20% lithium, production capacities reported in tons per year represent large differences in the actual lithium content of the product. For that reason, capacities were reported based on the lithium content of the products also known as contained lithium.

Australia

Lithium Australia Ltd. (LAL), a subsidiary of Greenbushes Ltd., mined high-grade, low-iron spodumene at its mine in Greenbushes, Western Australia. LAL produced two ore concentrate products through a flotation process for sale to the ceramics and glass industry. The majority of the company's spodumene concentrate was used in the

TABLE 3—Continued

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY

Compound and country	1988		1989	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Lithium metal[3]—Continued				
United Kingdom	—	—	201,128	—
Total	—	—	537,557	—
Other:				
Argentina	7,943	$15,904	—	—
Australia	85,406	217,572	—	—
Belgium	50 517	63,231	—	—
Brazil	123,302	206,387	—	—
Canada	1,357,388	2,132,539	—	—
China	—	—	—	—
Colombia	3,115	6,074	—	—
Denmark	—	—	—	—
Ecuador	11,000	20,500	—	—
France	94,520	91,761	—	—
Germany, Federal Republic of	210,198	399,073	—	—
India	3,000	5,505	—	—
Iraq	1,789	3,181	—	—
Ireland	440	2,260	—	—
Israel	353	12,091	—	—
Italy	30	1,980	—	—
Jamaica	9,830	25,409	—	—
Japan	87.109	830,872	—	—
Jordan	—	—	—	—
Korea, Republic of	1,533	17,343	—	—
Mexico	400,179	927,616	—	—
Netherlands	189,739	369,826	—	—
Nigeria	—	—	—	—
Pakistan	29,608	55,756	—	—
Philippines, Republic of	20,000	14,910	—	—
Saudi Arabia	12,641	22,531	—	—
Singapore	36,125	75,358	—	—
South Africa, Republic of	50,603	94,060	—	—
Sweden	—	—	—	—
Switzerland	7,714	13,500	—	—
Taiwan	92,189	311,104	—	—
Trinidad	62,200	141,791	—	—
Turkey	110	16,390	—	—
United Arab Emirates	32,000	15,500	—	—
United Kingdom	379,088	953,413	—	—
Venezuela	44,398	135,062	—	—
Yugoslavia	284	92,359	—	—
Total	3,404,351	7,290,858	—	—

[1] Data may not add to totals shown because of independent rounding.
[2] Pharmaceutical-grade lithium carbonate.
[3] According to the Journal of Commerce Port Import/Export Reporting Service.

Source: Bureau of the Census.

manufacture of black and white television picture tube glass and pyroceramics in the Pacific rim countries and Europe. LAL sold to the same countries glass grade concentrate with lower lithium content for consumption in container glass. Sales and production continued to expand significantly, as they have every year since production began in 1982.[1]

Bolivia

Industria Minera Tierra Ltda., a Bolivian company, and a U.S. company expressed interest in developing the Salar de Uyuni, the world's largest salt flat. Early in the year, Industria Minera Tierra requested permission from the Bolivian Government to build a pilot plant for the production of 40 tons of lithium carbonate per year. The Government showed interest in joint-venture arrangements by announcing plans to call for international bids. At yearend, the Government of Bolivia and Lithco were negotiating for a joint-venture operation in the Salar. Lithco's plans included an exploration program and, possibly, a 37,000-ton-per-year plant for recovery of lithium carbonate from the evaporated brines. Preliminary studies of the Salar de Uyuni, which is more than 3,600 meters above sea level, indicated reserves of 5.5 million tons of lithium, 110 million tons of potassium, and 3.2 million tons of boron.[2]

Canada

Tantalum Mining Corp. (Tanco) has been mining spodumene concentrates at its mine near Bernic Lake in southeastern Manitoba. Since mining began in 1984, Tanco has grown to become the largest supplier of lithium ore concentrates to the U.S. ceramics and glass industry. The Canadian spodumene was similar to the material mined in Australia (high-grade spodumene with very low iron content), making the concentrates ideal for direct application in the ceramics and glass industry.

Chile

Cyprus Foote Mineral Co. bought the remaining shares of its lithium brine operation at the Salar de Atacama, Sociedad Chilena de Litio Ltda. (SCL) to become the sole owner. Cyprus Foote, formerly Foote Mineral Co., has produced lithium carbonate

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF LITHIUM-BEARING MATERIALS, 1988

(Kilograms and thousand dollars)

	Compound							
	Lithium ores		Lithium compounds		Lithium salt		Lithium metal	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	4,425,085	413	231	10	—	—	—	—
Canada[2]	15,975,570	1,667	—	—	—	—	—	—
Chile	—	—	7,102,102	6,259	—	—	—	—
China	—	—	39,683	83	—	—	—	—
France	—	—	5,078	125	13,200	9	8,571	17
Germany, Federal Republic of	—	—	30,336	388	—	—	—	—
Japan	—	—	3,739	122	55	2	—	—
Luxembourg	—	—	65	1	—	—	—	—
Mexico	—	—	218	23	—	—	—	—
Namibia	905,962	24	—	—	—	—	—	—
United Kingdom	—	—	9,075	97	252	3	6,687	14
Zaire	79,808	2	—	—	—	—	—	—
Zimbabwe	10,273,839	943	—	—	—	—	—	—
Total	31,660,264	3,049	7,190,527	7,108	13,507	14	15,258	31

[1] Customs value.
[2] Spondumene concentrate.

Source: Bureau of the Census.

from the brines from this Salar since 1984. The project originated as a joint venture between Foote and Corporación de Fomento de la Producción (CORFO), a Chilean Government agency. Production capacity for lithium carbonate increased steadily from a 6,300-ton-per-year capacity to reach the current level of 9,100 tons per year. SCL expanded the evaporation ponds prior to another expansion at the carbonate plant. Further capacity expansion to 11,800 tons per year should be completed in 1990.[3]

Minera Salar de Atacama Ltda., the consortium formed by AMAX Exploration Inc. (United States), CORFO, and Molibdenos y Metales S.A. (Chile), completed studying the feasibility of developing another lithium operation on the Salar in 1988. Evaluations of the results were analyzed, and a decision from AMAX to pursue the project was expected in 1990.[4]

Namibia

Southwest Africa (SWA) Lithium Mines produced petalite concentrate at its Rubicon Mine near Karibib. Low-grade ores were beneficiated through a flotation process, while high-grade ores were hand picked. Small amounts of two other lithium ores, lepidolite and amblygonite, were other products. The Federal Republic of Germany imported most of these ores. High-grade lepidolite was handpicked at the company's Helicon Mine for export to Western Europe and Japan.[5]

Zimbabwe

Bikita Minerals Ltd. mined petalite, another lithium ore, near Masvingos. Although the ore reserves were becoming depleted, installation of a dense-media separator made it possible to recover lithium in the form of petalite averaging about 4.4% lithium oxide from a stockpile of previously rejected material. This extended the estimated mine life 30 years. Hand sorting, the method used since the mining began in 1916, amassed a stockpile of over 1 million tons that could be recovered with a significant savings in mining

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF LITHIUM-BEARING MATERIALS, 1989

(Kilograms and thousand dollars)

	Compound			
	Lithium carbonate		Lithium hydroxide	
	Quantity	Value[1]	Quantity	Value[1]
Chile	3,236,541	6,337	—	—
Germany, Federal Republic of	52	4	2,888	22
India	17,500	81	—	—
Japan	127	26	9,401	57
Sweden	—	—	545	27
Switzerland	72,000	175	10,348	58
United Kingdom	25	6	—	—
Total	3,326,245	6,629	23,182	164

[1] Customs value.

Source: Bureau of the Census.

TABLE 6

WORLD LITHIUM ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 1989, RATED CAPACITY[1]

(Metric tons of contained lithium)

North America:	
United States[2]	5,600
Canada	500
Total	6,100
South America:	
Argentina[e]	10
Brazil[e]	290
Chile	1,700
Total[e]	2,000
Europe:[e]	
Portugal	18
U.S.S.R.[3]	1,089
Total[4]	1,100
Africa:	
Namibia[e]	30
Zimbabwe	730
Total	760
Asia: China[e 3]	730
Oceania: Australia	1,300
World total[4]	12,000

[e] Estimated.
[1] Includes capacity at operating plants as well as plants on standby basis.
[2] Figures for the United States include 1,500 metric tons of capacity that has been idle since 1986.
[3] These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available. Output from China and the U.S.S.R. has never been reported.
[4] Data do not add to total shown because of independent rounding.

TABLE 7

LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY[1]

(Metric tons)

Country[2]	1985	1986	1987	1988[p]	1989[e]
Argentina (minerals not specified)	35	184	178	119	120
Australia, spodumene	11,835	12,703	22,279	[r e]30,000	40,000
Brazil:					
Amblygonite	159	49	52	[e]50	50
Lepidolite	26	30	[3]	[3]	—
Petalite	1,323	1,614	2,946	[r e]1,700	2,000
Spodumene	107	366	505	[e]400	400
Canada, spodumene[e 4]	4,600	7,500	11,500	14,000	14,000
Chile, carbonate from subsurface brine	4,508	4,458	6,139	7,332	8,000
China (minerals not specified)[e 5]	15,000	15,000	15,000	15,000	15,000
Namibia:					
Amblygonite	49	52	106	147	150
Lepidolite	71	52	61	18	20
Petalite	1,753	751	749	1,477	1,200
Portugal, lepidolite	4	[e]27	—	—	—
U.S.S.R. (minerals not specified)[e 5]	55,000	55,000	55,000	55,000	55,000
United States, spodumene and subsurface brine	W	W	W	W	W
Zimbabwe (minerals not specified)	27,910	32,760	14,959	15,073	15,500

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing proprietary data.
[1] Table includes data available through Apr. 9, 1990.
[2] In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.
[3] Revised to zero.
[4] Estimates based on imports by the United States.
[5] These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available. Output by China and the U.S.S.R. has never been reported.

costs after installation of the new device. Hand sorting continued to be used only for special small orders of minerals other than petalite.[6]

CURRENT RESEARCH

Research continued in areas believed to possess the greatest potential for the lithium industry. Martin Marietta Corp. of Baltimore, MD, developed a new family of aluminum-lithium (Al-Li) alloys, named Weldalite, targeted for use in aerospace applications, and, specifically, space launch systems. The alloys were the strongest known wrought aluminum products available, according to Martin Marietta. Reynolds Metals Co. received the license for exclusive production. During testing, Weldalite maintained superior strength over the wide range of temperatures required for space applications. The alloys were lightweight due to the lithium content, and weldable, making them attractive for use in fuel and oxidizer tanks for space vehicles. Reynolds planned to produce ingot, sheet, plate, and extrusions of Weldalite at its new casting facilities in McCook, IL. The McCook facilities were upgraded to prepare Reynolds to become a leading supplier to the aerospace industry.[7]

Because forged metal parts have been preferred to castings or machined parts due to superior tensile strength and toughness, techniques have been developed for forging Al-Li alloys. Boeing Commercial Aircraft Co. tested tow fittings forged from Al-Li 2090 alloy that should withstand the high load stress of towing and the extensive environmental exposure during takeoffs and landings on aircraft. Huntington Alloys International developed two powder metallurgy Al-Li alloys for forgings. The company tested its 905XL hot-die forgings in aircraft components because of its low density and high strength. It considered its 9052 alloy for torpedo bodies and hulls because of its good corrosion resistance.[8]

Several organizations improved existing battery technology or developed new products. Long-life thermal batteries have powered weapons and spacecraft since World War II. These batteries can remain inactive for 30 years without discharge, and upon activation when the electrolyte melts, produce power for a few minutes to 1 hour. In the late 1970's, Sandia National Laboratories developed a lithium-silicon alloy and iron disulfide battery to replace the original calcium-calcium chromate thermal battery. The new design weighed 75% less than the calcium battery, but experienced troublesome voltage spikes. By addition of lithium oxide to the cathode material, control of heat input to the battery, and puri-

fication of the iron disulfide, the laboratory eliminated the voltage spikes.[9]

Researchers at the University of California at Berkeley developed a new battery that reportedly could make electric vehicles practical. The new battery, which could produce up to 30% more power per ounce than current systems and weighs significantly less, consisted of thin films of lithium, polyethylene film, and a disulfide polymer that are sandwiched together. A series of thin cells could be layered together to form larger batteries. The improved design reduced temperature requirements for electric vehicle batteries. The polymer battery could lower the operating temperature requirements from 700° F to between 176° F and 212° F. Coin cells like the ones found in watches and calculators should be available in 2 years using the new technology; larger size cylinders and vehicle batteries were expected to be available later.[10]

Sanyo Energy Corp. began offering a rechargeable lithium/manganese dioxide (Li/MnO_2) battery. The new product possessed a low self-discharge rate and high voltage in relation to size. One Li/MnO_2 battery should replace two nickel/cadmium batteries and provide two to three times the energy density.[11]

Research continued in other areas, which, if developed, hold potential for requiring large amounts of lithium. Integrated, or waveguide, optics are the optical equivalent of the electronic integrated circuits. As more information is transported via optical fibers, devices will be developed to process that information through optical rather than electronic means. Lithium niobate has been identified as a prime material for integrated optic substrates.[12] Lithium should be an important material in the development and operation of nuclear fusion reactors. Westinghouse Hanford Co., in Richland, WA, developed a device called the Materials Open Test Assembly (MOTA) to test different materials for use in fusion reactors. Samples of material would be placed in a reactor plant and irradiated for more than 1 year. Tests would determine tritium recovery rates from lithium oxide test canisters. Other fusion materials will be tested in other canisters.[13]

OUTLOOK

The aluminum industry experienced a slowdown in 1984, and, as a result, domestic lithium consumption decreased dramatically that year. Since that time, lithium consumption has expanded at an average of about 5% per year. This increase was due primarily to the recovery of the aluminum industry as well as increased demand for lithium compounds and minerals in the ceramics and glass industry. Similar increases are expected for the future.

Demand for lithium metal for batteries and alloys should increase, but total consumption of the metal will remain small in comparison to the demand for lithium chemicals. Markets should remain relatively stable with average growth, although new applications for mineral concentrates could increase demand for those materials significantly in the next few years. Lithium demand could increase dramatically if any of the new technology areas such as nuclear fusion were perfected. This is not expected to occur within the remainder of this century, and probably not within the next 25 years.

[1] Lithium Australia Ltd. Annual Report, 1989, 28 pp.

[2] U.S. Embassy, La Paz, Bolivia. Lithium Corp. of America Signs Preliminary Contract to Exploit the Salar of Uyuni. State Dep. Telegram 15280, Nov. 24, 1989, 2 pp.

[3] Cyprus Minerals Co. Annual Report, 1989, 48 pp.

[4] U.S. Embassy, Santiago, Chile. AMAX Approaches Final Decision Point on Major Lithium and Mixed Salts Project. State Dep. Telegram 09061, Sept. 8, 1989, 2 pp.

[5] Murray, R. Namibia's Mineral Potential—Independence Brightens Development Prospects. Ind. Miner. (London). No. 266, 1989, p. 87.

[6] Russell, A. Bikita Minerals—35 Years on and Still Further Potential. Ind. Miner. (London). No. 249, 1988, pp. 63-71.

[7] Huskonen, W. D. Reynolds Launches Space Age Alloy. Metal Producing (Cleveland), v. 27, No. 9, 1989, pp. 43-44.

[8] Hunt, M. Forgers Fabricate Future Forms. Mater. Eng., v. 106, No. 3, 1989, pp. 43-46.

[9] Sandia Science News. Changes Improve Performance in Long-life Thermal Batteries. V. 24, No. 9, 1989, pp. 2, 4.

[10] Naj, A. I. California Team Claims Advance for New Battery. The Wall Street Journal (New York). Dec. 4, 1989, p. B4.

[11] Advanced Battery Technology. New Products and Literature (Cooperstown). V. 25, No. 11, 1989, p. 6.

[12] Duchart, B., and I. Weir. Engineering Gems—An Optical Engineers Best Friend? Materials Edge (London), No. 14, 1989, pp. 21-23.

[13] Materials Engineering. Fusion Energy Materials. V. 106, No. 3, 1989, pp. 9, 12.

OTHER SOURCES OF INFORMATION

Bureau of Mines Publications

Lithium. Ch. in Mineral Commodity Summaries, annual.

Lithium Availability—Market Economy Countries.

Other Sources

Canadian Minerals Yearbook, annual.
Chemical Marketing Reporter, weekly.
Chemical Week, weekly.
Engineering and Mining Journal, monthly.
European Chemical News (London), monthly.
Industrial Minerals (London), monthly.
Metal Bulletin (London)
Metals Week, weekly.
Mining Annual Review (London)
Mining Engineering, monthly.
Mining Journal (London)
Mining Magazine (London)
The Northern Miner (Canada), weekly.
Roskill Information Services Ltd. (London)
World Mining, monthly.